

October 09, 2006

TO: D. Morris  
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SUBJECT: Kepler X-band Supportability Study

The Resource Analysis Team has completed a special study to analyze the ability of the DSN to provide support for the Kepler mission utilizing X-band assets.

### **Summary of Results**

The Kepler mission is forecast to have good support if 12 hours of support are needed. There are seasonal viewperiod limits annually in both the Northern and Southern hemisphere within the DSN complexes due to the 20 degree horizon limits imposed on this study. There were periods in 2009, 2010 and 2012 where some missions will impact Kepler support.

### **Background**

The Kepler mission is investigating the usage of X-band assets to provide support to the mission if Ka-Band communications are not possible. This study is in response to a request to determine the supportability during the 4-year life of the prime mission from November 1, 2008 through December 1, 2012 of the mission. This study focuses on the Science Operations phase from December 2008 - November 2012. The use of X-band communications requires the use of 20 degree horizon mask viewperiods, which were used for this study.

The Kepler mission requested analysis (A) for one 12-hour X-band pass per day for the entire four year mission duration starting with 34 meter in years 1 and 2, moving to 70 meter for years 3 and 4. The Kepler mission also requested a second analysis (B) for two 8-hour X-band passes per day for the entire four year mission duration solely using any X-band 34 meter subnet.

### **Methodology**

Due to the 20 degree horizon limitation and the resultant reduced viewperiods with the desire to turn this analysis around rapidly, the analysis forecasted support for two 6-hour passes per day for the entire four year mission duration with 34 meter antenna. In addition, the supportability by the 70 meter subnet for the entire 4 year Kepler mission duration was forecast.

Several support scenarios were built utilizing several combinations of X-band capable assets and separate subnets. The 34 meter and 70 meter subnets were analyzed separately to determine the supportability percentage for Kepler mission. In addition, the combined subnets were also analyzed to find the overall supportability from all the DSN resources.

There is semi-annual seasonal limited coverage resulting from the 20 degree horizon limits where pass durations were changed from 6 hours to 4 hours in order to use all complexes as long as possible. Canberra's seasonal coverage limit occurs around week 04 through week 15 of each year beginning with year 2009 and ending in year 2012. Madrid's seasonal limited coverage occurs around week 35 – week 40.

## Analysis

Analysis used the updated mission set database from the August 2006 Resource Allocation Review Board (RARB). Analysis was accomplished by running forecasts for years 2008 – 2014. For the weeks that are above 80% supportability, it should be negotiable in the mid-range allocation process. The DSN Antenna Downtime Status and Forecast was also used to show the downtimes and critical events that may affect this study relevant to Kepler mission.

The results indicated that supportability of Kepler mission from 2009 – 2012 has a trend of semi-annual seasonal limited coverage resulting in low supportability percentage. The Canberra and Madrid complexes and the 20 degree horizon mask is the reason for limited view periods and low supportability. In addition, for many weeks after launch there are viewperiod limits at Canberra due to the 20 degree limit. Even with shorter pass durations, the forecast results in areas where supportabilities are low.

The following indicates the seasonal limited low supportability by year and corresponding Complex, also see Figure 1:

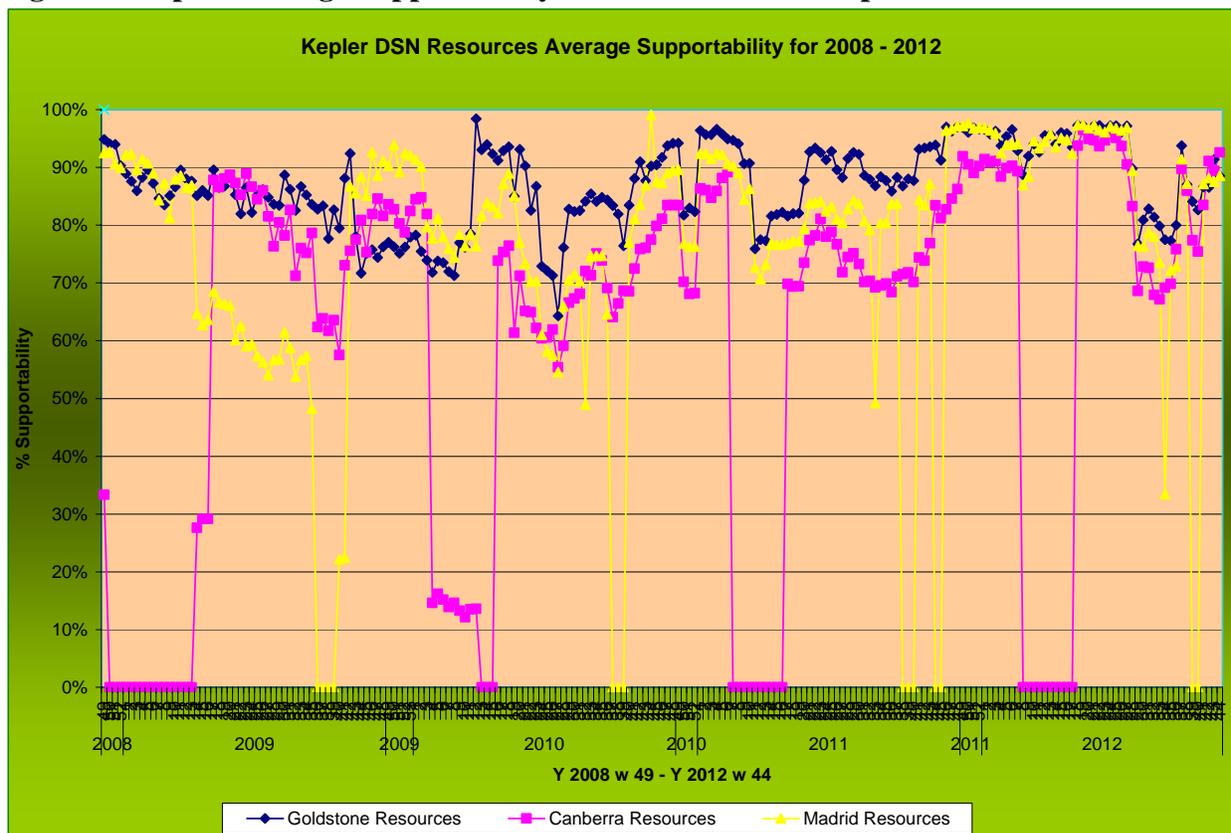
**2009:** week 01 – week 12 Canberra, week 35 – week 38 Madrid

**2010:** week 04 – week 14 Canberra, week 36 – week 38 Madrid

**2011:** week 06 – week 15 Canberra, week 36 – week 39 Madrid

**2012:** week 06 – week 16 Canberra, week 37 – week 39 Madrid

**Figure 1: Kepler Average Supportability From Each DSN Complex 2008 - 2012**



There are episodes of major Mission Events and viewperiod overlaps which leads to contentions for DSN Resources in year 2009, 2010, and 2012. Also the semi-annual seasonal limited coverage resulting from the 20 degree horizon limits contribute to the low supportability trend.

The following weeks have low supportability from viewperiod overlaps with other missions and seasonal limited coverage from the 20 degree horizon limits for Kepler:

- **2009:** During weeks 21 – 29 and weeks 35 – 40 all three complexes have low supportability due to viewperiod contentions with the following Missions but not limited to them: Advance Composition Explorer, Cassini, Dawn, Mars Missions (Odyssey, Spirit, Opportunity, Express, Global Surveyor, and Science Laboratory), Messenger, New Horizons, SOHO, Stereo Behind, Voyager 1 and 2.
- **2010:** During weeks 04 – 11 reduced supportability is due to limited Canberra Resources and viewperiods. In weeks 23 – 28 all three complexes have low supportability due to contentions with the following Missions but not limited to them: Cassini, Dawn, Mars Missions (Odyssey, Spirit, Opportunity, Express, Global Surveyor, Science Laboratory), Messenger, Voyager 1 & 2, and Wind.
- **2012:** During weeks 33 – 40 have low supportability at all three complexes with the following Missions: Advance Composition Explorer, Dawn, Mars Missions (Odyssey, Spirit, Opportunity, Express, Global Surveyor, Science Laboratory, Mars Reconnaissance Orbiter), New Horizons, Voyager 1 & 2.

A review of subnet supportability shows the average from year 2008 - 2012:

- **34H** – Supportability from 2008 – 2010 averages about 83% and slightly improves to 82% from 2010 – 2012, this shows a good overall consistent supportable percentage.
- **34B1** – Supportability from 2008 – 2010 averages about 57% and slightly improves to 60% from 2010 – 2012.
- **70M** – Supportability from 2008 – 2010 averages about 56% and improves to 83% from 2010 – 2012, this is mostly due to planned 70 meter subnet downtime at each complex.

The third analysis focused on the supportability of using only the 70 meter antenna subnet, please see Figure 2 and 3. The 70 meter low supportability is due primarily to the downtimes scheduled between 2008 – 2010 (Figure 2), but the low supportability beyond 2010 (Figure 3) are due to other contentions on the 70 meter subnet and primarily due to the semi-annual seasonal limited coverage resulting from the 20 degree horizon limits at Canberra and Madrid.

- **70M Total Average** – Supportability from 2008 – 2010 averages about 56% and improves to 83% from 2010 – 2012, this is mostly due to 70 meter subnet downtime at each complex occurring in 2008 – 2010.
- **DSS – 43** downtime from 2008 week 40 – 2009 week 13 causes DSN Users to seek alternate resources such as DSS63 and DSS-14. See figure 2.

Figure 2: 70 meter Subnet Supportability 2008 wk 49 – 2012 wk 44

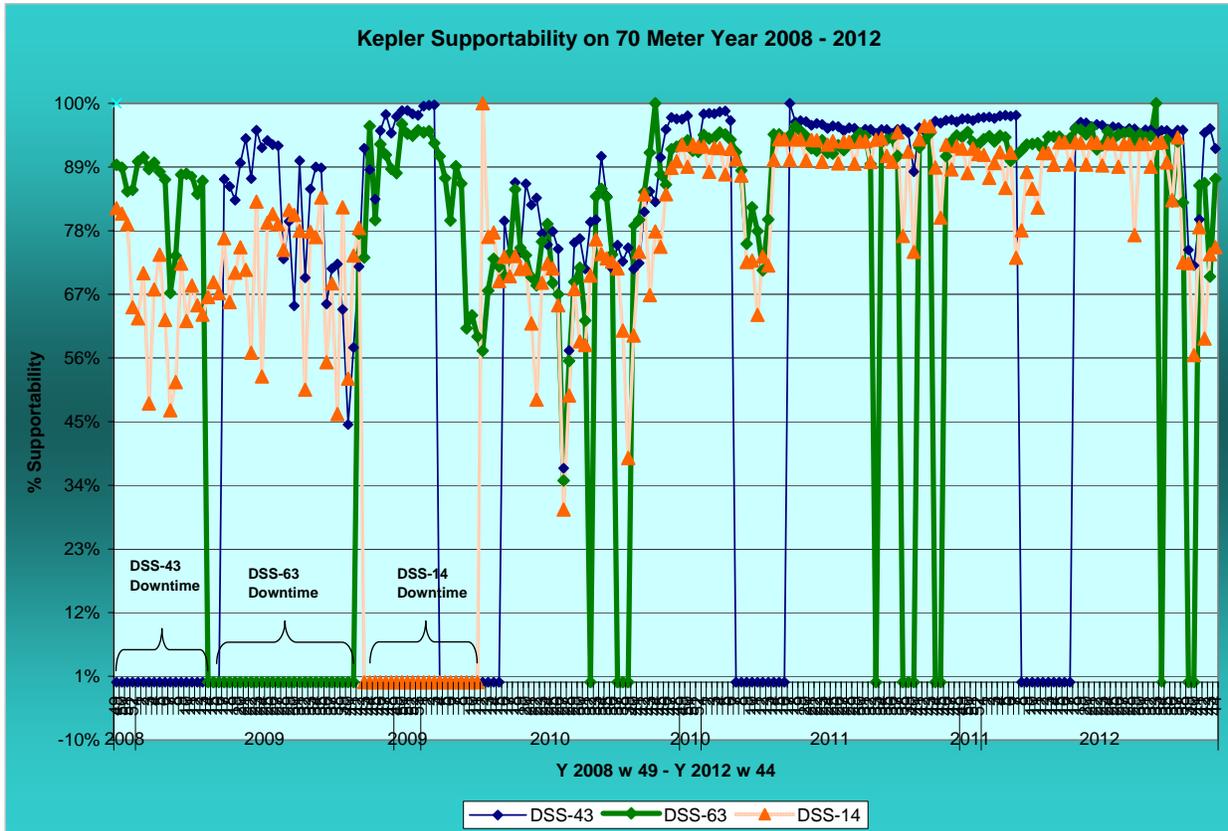
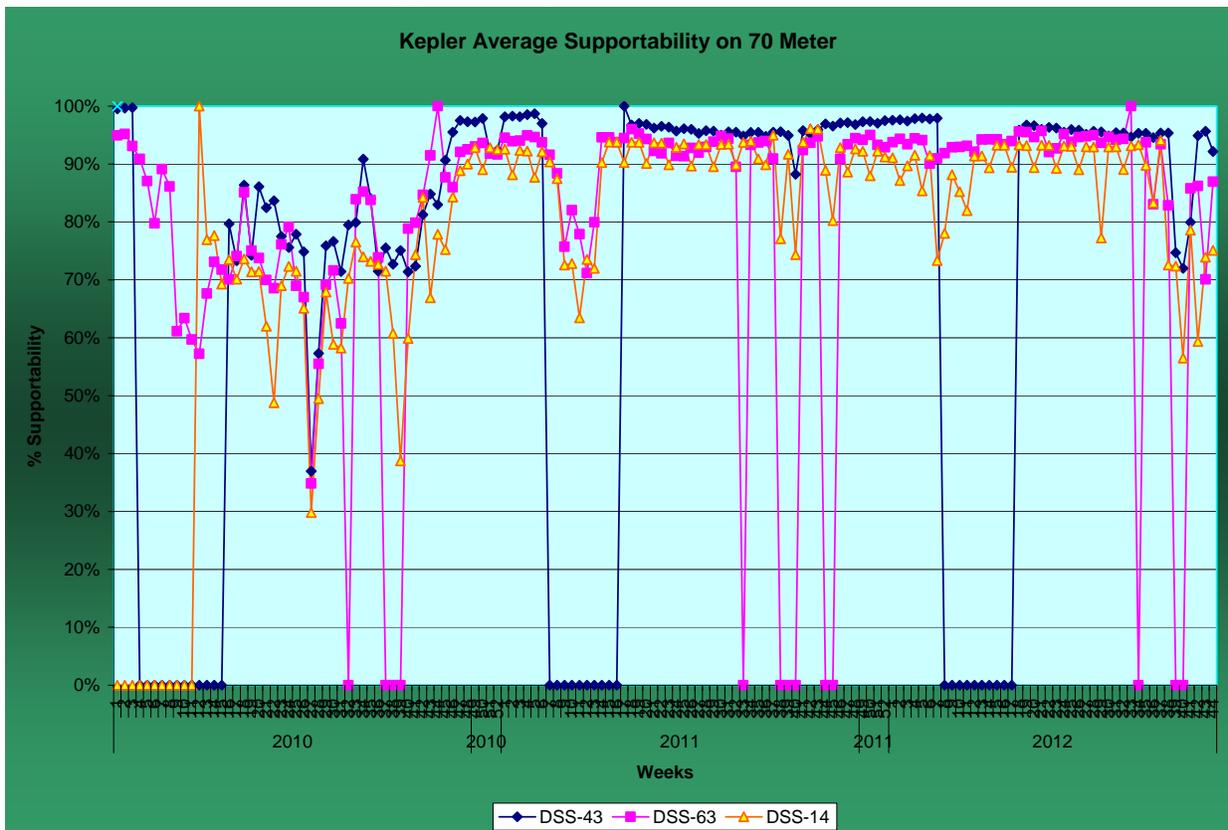


Figure 3: 70 meter Subnet Supportability 2010 wk 01 – 2012 wk 44



## **Conclusion**

The Kepler mission requested two analysis cases: (Case B) Daily 16 hours on the 34 meter subnets and (Case A) Daily 12 hours X-band support for the entire four year mission duration starting with 34 meter in years 1 and 2, moving to 70 meter for years 3 and 4.

RAPS recommends Kepler use a mix of both the 34 meter and 70 meter versus just using only the 34 meter or just the 70 meter subnet in order to improve the supportability percentage. RAPS recommends Kepler use shorter pass durations when there are seasonal viewperiod limitations, but increase the duration of passes at the other complexes to cover the hours required for prime mission especially when the requested hours do not have to be continuous coverage.

As always, the results of this study are subject to change, in that network loading changes as requirements for planned missions are input and updated and periods of antenna downtime are identified. We will continue to work with Kepler and other users of the DSN to maximize the time available for each individual user.